

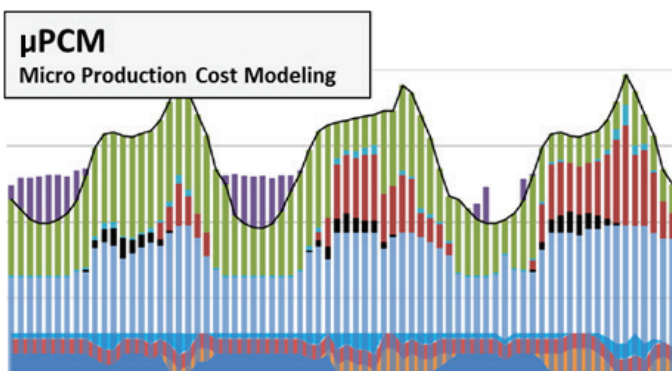


ENERGY STORAGE INDUSTRY - ACCEPTANCE & ANALYTICS CAPABILITIES AND SERVICES

Sandia capabilities and services can assist a utility in implementing an optimal energy storage system (ESS) solution into their grid. Our engineering and economic analysis tools can provide clients with the information to properly size/place storage within the network and enable rapid return on investment.

MARKET-AREA AND BEHIND-THE-METER ANALYSIS

Sandia has developed an optimization framework in MATLAB® and Python to evaluate the maximum potential revenue of energy storage systems from providing different grid services (e.g., energy arbitrage, frequency regulation, forward capacity) and behind-the-meter services (e.g., time-of-use management, demand charge reduction, power quality). If the historical data are available, this optimization provides the upper bound on potential revenue that can be used to evaluate different control strategies. In the scenarios where forecast data are given, the optimization framework can be used in energy management system to optimally schedule and dispatch the energy storage systems.



Sandia's μPCM capability examines financial interactions between microgrids and larger energy markets—assessing and packaging the services that distributed resources provide so that their costs/benefits are monetarily quantifiable using traditional tools. μPCM can model how multiple distributed energy technologies would bid as an aggregated resource in a traditional energy market, thereby estimating the costs/benefits of doing so.

VERTICALLY INTEGRATED UTILITY

Sandia can help a utility accurately estimate the potential cost savings from incorporating energy storage into their grid by performing production cost modeling for a baseline case and then a number of potential storage scenarios. Typical applications include arbitrage, frequency regulation, and spinning reserve. The resulting predictions of reduced operating costs that result from including energy storage in the system yields its value.

Accurately modeling renewable energy generation variability can reveal the increased value of energy storage. This analysis can also be used to estimate optimum sizing and placement of a storage system. For high penetrations of renewables, Sandia can also perform stochastic unit commitment analysis, which typically results in a cost savings of ~3% over a deterministic case.

ENERGY STORAGE FOR GRID SECURITY

Sandia can perform dynamic simulations to identify the optimal storage system sizing and placement to meet grid performance requirements, e.g., minimum frequency excursion after a generator drop. The grid is modeled using dynamic simulation software and data analysis is performed in MATLAB®.



MICROGRID DESIGN TOOL

Sandia has developed a Microgrid Design Tool (MDT) that will assess existing stakeholder energy infrastructure using a performance risk analysis, which determines if the existing stakeholder energy infrastructure is at a low, medium, or high risk, based on a certain threat (such as weather). This tool can help the utility develop optimal candidate microgrid topologies—identifying minimal-cost microgrid designs that satisfy target static reliability criteria.

With the MDT, Sandia can help any utility develop conceptual energy surety system designs based on stakeholder-defined objectives such as cost, performance, and reliability for your energy needs. The MDT effectively searches through a large design space for efficient alternatives and investigates the



simultaneous impacts of multiple design decisions. MDT results allow a designer to understand the trade-off relationships between design objectives (cost, performance, etc.) and have defensible, quantitative evidence for decisions. Energy Storage System Project Design Procurement Sandia experts can apply their broad capabilities and extensive toolset to help a utility acquire an energy storage system (ESS) to meet their design goals and use case. We can

- Provide data on which technologies best meet the anticipated application. We will review intended applications and work with a client to discuss appropriate technologies and capacities.
- Assist in developing and reviewing a client's request for proposals (RFP). Sandia can support the utility in developing use-case criteria, work breakdown structures, defining the scope of work, and other technical criterion to insure a successful RFP.
- Assist in ESS design and procurement. Sandia will work with a client to review contractor construction design and contracting strategy.
- Assist in the design of data acquisition systems. Sandia expertise can help a client ensure correct metering is installed in strategic locations to effectively measure and record system operational data.
- Assist in developing the ESS commissioning plan. We will work with contractor and system owner to devise factory acceptance testing plans, installation start-up and

commissioning plans, and develop functional application testing plans.

- Analyze test data once the system is operational. By using tools described above, our experts can conduct analyses to determine the system's technical and economic performance and ways and means to optimize system performance.
- Develop control algorithms. Based on a client's needs, we can develop optimization algorithms to maximize their ESS: revenue or benefit to the grid.

ENERGY STORAGE TESTING AND ANALYSIS

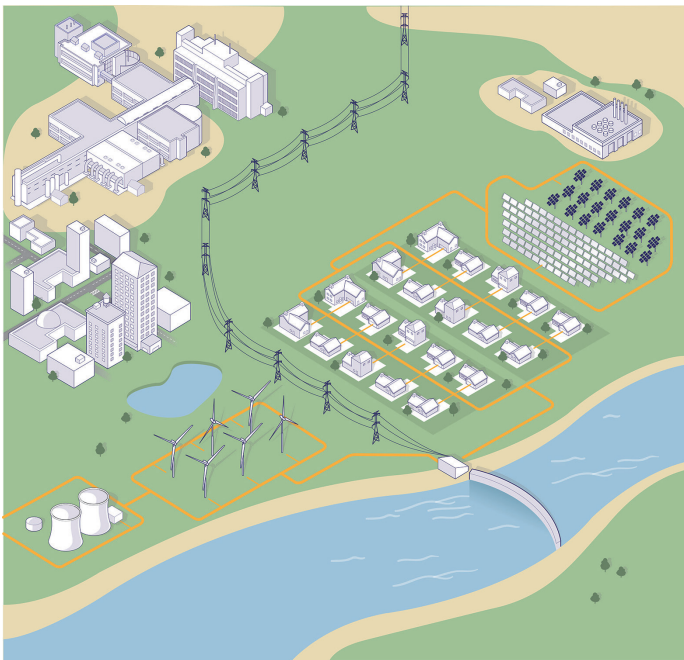
Sandia is home to the technical expertise and equipment to provide a comprehensive suite of ESS testing and analysis:

- Cell and module analysis, up to 48 VDC 2000 A within a controlled environment (chamber).
- Spectral impedance measurement.
- Test ESS up to 1.5 MW 480 V 3-phase AC. Sandia's energy storage test pad is capable of testing ESS in grid or microgrid configuration. We can test and analyze system in various applications, and we can also perform factory-acceptance testing, and project-location testing
- On-site commissioning support.
- Safety evaluations.
- Provide third party independent evaluations, analysis, and reports.

MATLAB and Simulink are registered trademarks of The MathWorks, Inc.

CONTACT:

Dan Borneo
drborneo@sandia.gov
 (505) 284-9880



Within a microgrid, ESS asset size and placement can affect overall system performance, return on investment, and interactions with the larger grid. Sandia capabilities can help a utility optimize its choices.